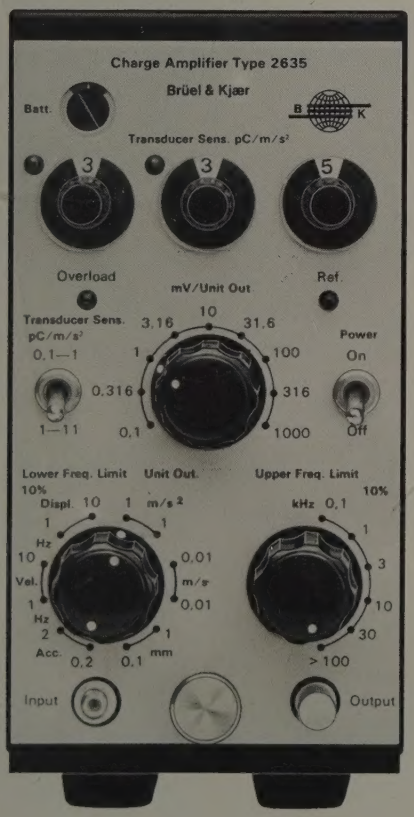
2635

Instruction Manual

Charge Amplifier Type 2635



A portable, low noise charge amplifier with self contained battery supply for use with piezoelectric accelerometers and other piezoelectric transducers. Accurate 3 digit conditioning networks permit dial-in of exact transducer charge sensitivity to give Amplifier output ratings of between 0,1 to 1000 mV/unit selectable in convenient 10 dB steps. Active integration networks are built-in for conversion of vibration acceleration to velocity and displacement signals. Calibration of portable recording equipment may be performed using an internal 160 Hz sinusoidal test source.

Brüel & Kjær

CHARGE AMPLIFIER
TYPE 2635

Revision April 1986

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Conditioning Amplifier (Battery Operated)

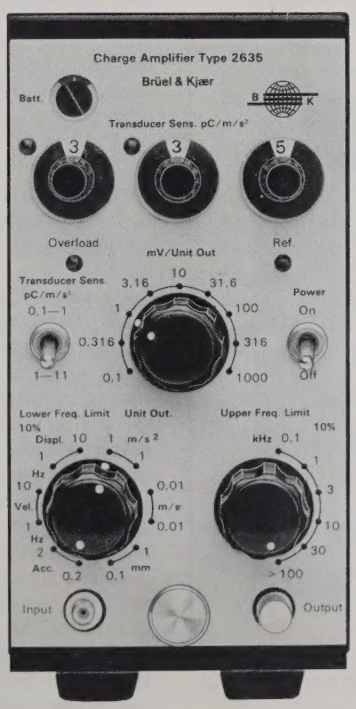
USES:

- Field and laboratory measurement of vibration in terms acceleration, velocity and displacement together with piezoelectric accelerometer and voltmeter or measuring amplifier
- Field recording of vibration and other signals together with portable tape recorders and level recorders
- Underwater sound measurements with hydrophone
- Mechanical impedance measurements

FEATURES:

- Charge Input
- 3 digit conditioning to transducer sensitivity
- Unified output ratings for simplified system calibration
- High sensitivity up to 10 V/pC
- Built-in integrators for displacement and velocity
- Switchable low and high frequency limits
- Built-in test oscillator

The Charge Amplifier Type 2635 is a comprehensively equipped, charge conditioning amplifier intended for general vibration measurements with a piezoelectric accelerometer input and for underwater sound measurements in conjunction with piezoelectric hydrophones. Its output will be routed to portable tape recorders and level recorders, electronic voltmeters, measuring amplifiers and frequency analyzers. It can be powered from internal batteries or an external DC power supply and is equally suitable for portable use in the field and for general laboratory use.



Description

Reference is made to the block diagram shown in Fig.1. The 2635 is a four stage amplifier consisting of an input amplifier, low-pass filter-amplifier, integrator amplifier, and output amplifier. An overload detector, test oscillator and power supply unit are also included.

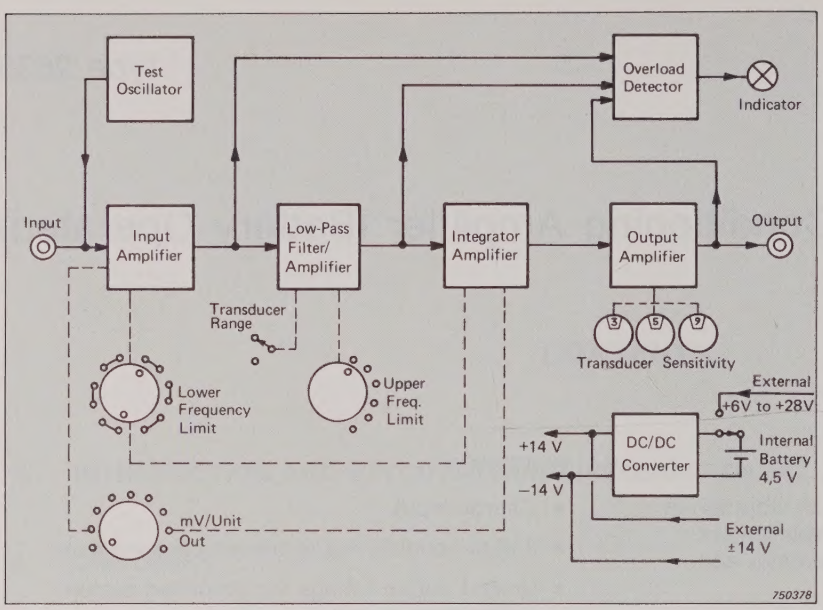


Fig. 1. Block diagram of Type 2635

Input

The input signal is fed to the amplifier via either a miniature coaxial socket on the front panel or a BNC socket on the rear panel. The charge amplifier input eliminates the reduction in transducer sensitivity due to the use of long connecting cables and makes recalibration of the system unnecessary when changing to cables of different length.

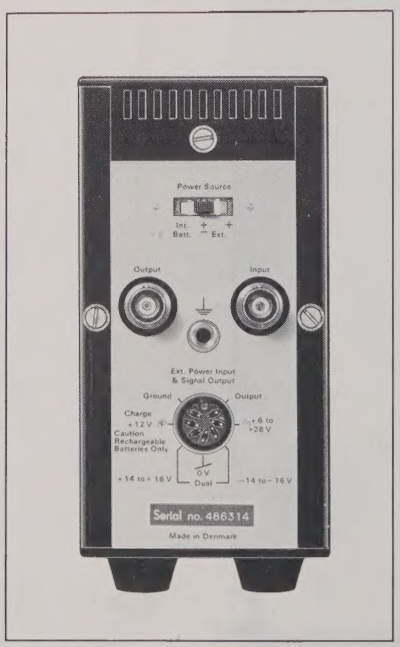


Fig. 2. Rear panel view of Charge Amplifier Type 2635

Where transducers with a high temperature transient sensitivity are used, the high-pass filter in the input of the 2635 can be switched from 0,1 Hz to 1 Hz (–3 dB) in order to reduce interference from signals originating from low frequency temperature fluctuations.

The overall gain of the 2635 is adjusted in the input and integrator amplifiers in order to provide a rated output level switchable between 0,1 mV/unit and 1 V/unit in 10 dB steps. With these nine positions, the output signal level can be adjusted to best utilize the limited dynamic range of tape recorders and to match the signal to the various input requirements of recorders, voltmeters, measuring amplifiers etc.

Low-pass Filter

Six switchable upper cut-off frequencies are provided by the low-pass filter, which is placed immediately after the input amplifier in order to filter out unwanted signal components before further amplification. The filter is a two-pole active circuit with a 12 dB/octave cut-off. It will, for example, be particularly valuable when measuring vibration on rotating machinery employing gears. In this case, frequency components above the band of interest can have appreciably higher levels than the measured signals. If these high frequency components are not filtered out at this stage they can be clipped by amplifier overload and create difference frequencies which lie in the band of interest so that they are not then separable from the required signal components.

The special low-pass filter to limit the frequency range to 100 Hz (–10%) will be used when tape recording vibration signals in the field for subsequent analysis in accordance with the new ISO 2631 (Guide for the evaluation of human exposure to whole-body vibration). These measurements are performed on passenger vehicles, tractors, and other machines where the human body as a whole is subjected to vibration.

The upper frequency limit of 200 kHz (–3 dB) is provided so that underwater sound measurements can be made in the field with hydrophones.

Integrator–Amplifier

This amplifier has three switchable modes of operation, linear (Acceleration), single integration (velocity), and double integration (Displacement). This amplifier also provides low frequency cut-off, switchable to either 1 or 10 Hz (–10%) in the velocity and displacement modes, in order to further suppress low frequency noise.

The low frequency limit is extended down to 0,1 Hz (–3 dB) in the linear mode so that the very low temperature transient sensitivity exhibited by the B & K Delta Shear® accelerometers and force transducers at these low frequencies can be utilized.

The frequency response of the integrators is shown in Fig.3.

Output Amplifier

The output amplifier features a three digit sensitivity adjustment network which enables the 2635 to be conditioned to suit transducer sensitivities between 0,1 and 11 pC/unit. This feature greatly simplifies the calibration and reading of a measuring system, especially when using transducers which have "odd" sensitivity values, i.e. non Uni-Gain® types.

It should be noted that the transducer conditioning and sensitivity adjustment is optimised for metric units throughout. However, an accelerometer sensitivity expressed in pC/g can be dialled into the 2635 and will give calibrated output in terms of g instead of ms^{-2}.

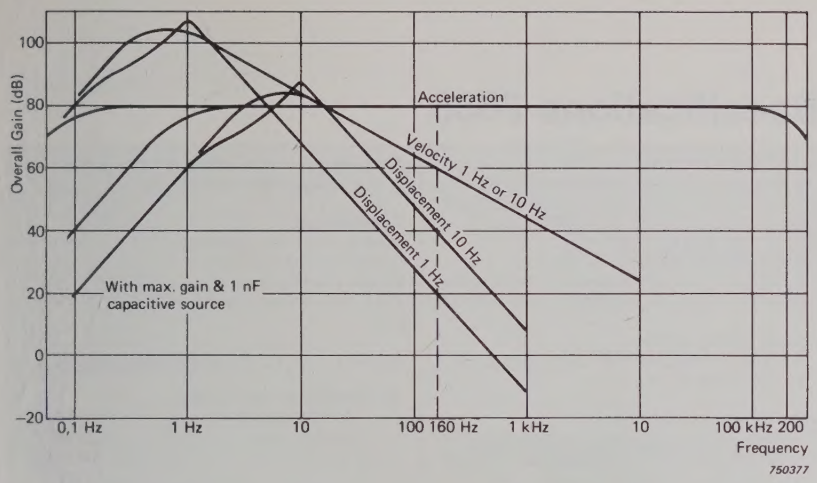


Fig. 3. Frequency response curves in linear position (acceleration), and with integrators for velocity and displacement. (Low pass filter at 100 Hz, 1 kHz, 3 kHz, 10 kHz and 30 kHz are not shown

The overlay SC 0418 can be stuck onto the front of the 2635 to simplify the subsequent calibration of the measurement chain.

The short-circuit protected output amplifier provides a low impedance signal to a miniature coaxial connector on the front panel and a BNC socket on the rear panel.

Overload Detector

The overload detector monitors an overload condition at the input amplifier, low-pass filter, and at the output amplifier so that overloads in various parts of the circuitry are not masked by filtering. Overload indication is by a light emitting diode on the front panel.

Test Oscillator

The 2635 is equipped with a push-button activated test oscillator which applies a 160 Hz sinusoidal signal to the input. The test frequency of 160 Hz is chosen so as to simplify checking in the velocity and displacement modes. At this frequency the output should be 20 and 40 dB respectively, lower than the output in the acceleration mode. See the frequency response in Fig.3. The oscillator level is factory adjusted to give an output level of 1 V RMS (for the prescribed sensitivity settings) which is used in the calibration and setting up of recording levels on the B & K portable tape recorders.

Power Supply

Three different power supply forms are possible:

1. Three standard 1,5 V cells (IEC Type R 20) are housed inside the cabinet, they supply, via the DC converter, positive and negative regulated supply voltages for the amplifiers. The dual polarity power supply ensures that the output signal is centered at ground potential with negligible DC offset. With standard batteries, the normal lifetime with intermittent use is approximately 100 hours. These can be replaced by rechargeable NiCd-cells which will be especially convenient where the preamplifier is used for long periods. A built-in voltage limiter allows the use of ordinary 12 V battery chargers (i.e. B & K ZG 0113) for recharging in-situ. Battery condition is displayed by an indicator on the front panel.

Fig.4. Three 2635's and a Portable Tape Recorder Type 7005 for on-site recording of machine vibration. The Portable Calibrator Type 4291 provides a reference vibration source for check-out of the whole measuring chain and allows the recording of a calibration signal on tape

2. An external + 6 V to + 28 V single polarity power supply may be used. When the 2635 is used in conjunction with a B & K measuring amplifier or frequency analyzer, the 12 V supply available at the preamplifier input socket can be used. In this case the output signal and power supply can be combined in one cable.

3. A well regulated ± 14 V power supply such as the B & K Type 2805 can be used to power the amplifiers directly, thus by-passing the DC converter.

The recharging voltage, and the + 6 V to + 28 V supply, and the ± 14 V supply are all applied through a 7 pin DIN socket on the rear panel.

Specifications 2635

CHARGE INPUT:
Via 10-32 NF and BNC coaxial socket
Max. Input: $\sim 10^5$ pC

SENSITIVITY CONDITIONING:
3 digit dial-in of transducer sensitivity from 0,1 to 10,99 pC/ms^{-2}

AMPLIFIER SENSITIVITY:
0,01 mV to 10 V/pC corresponding to –40 to +80 dB with transducer capacitance of 1 nF

CALIBRATED OUTPUT RATINGS:
Selectable in 10 dB steps
Acceleration: 0,1 mV to 1 V/ms^{-2}
Velocity: 10 mV to 100 V/ms^{-1}
Displacement: 0,1 mV to 10 V/mm

SIGNAL OUTPUT:
Via 10-32 NF and BNC coaxial socket
Max. Output: 8 V (8 mA) peak
Output Impedance: $<1\ \Omega$
DC Offset: $<\pm 50$ mV

FREQUENCY RANGE:
Acceleration*: Switchable 0,2 or 2 Hz to 100 kHz
Velocity: Switchable 1 or 10 Hz to 10 kHz
Displacement: Switchable 1 or 10 Hz to 1 kHz
–10 % limits quoted — see Fig. 3

LOW-PASS FILTER:
Switchable –10 % frequency limits of 100 Hz, 1 kHz, 3 kHz, 10 kHz, 30 kHz and >100 kHz with attenuation slope of 40 dB/decade

INHERENT NOISE (2 Hz to 22 kHz)
$5 \cdot 10^{-3}$ pC referred to input with maximum sensitivity and 1 nF transducer capacitance

TEST OSCILLATOR:
160 Hz (ω = 1000 rad/s) sinusoid, factory preset for test level of 1 V

OVERLOAD INDICATOR:
Overload LED lights when input or output of amplifier is overloaded by signals of too high a peak level

RISE TIME: $\sim 2{,}5\ V/\mu s$

ENVIRONMENTAL CONDITIONS:
Temperature Range: –10 to +55°C (+14 to 131°F)
Humidity: 0 to 90% RH (non-condensing). For use in high humidities a 3 W heater may be fitted on special order

POWER REQUIREMENTS:
Int. Battery: Three 1,5 V Alkaline Cells QB 0004 (IEC LR20). Provide approximately 100 hours use
Ext. Source: +6 to +28 V (55 mA) single or ±14 V (14 mA) dual polarity DC

DIMENSIONS:
Height: 132,6 mm (5,22 in)
Width: 69,5 mm (2,74 in)
Depth: 200 mm (7,87 in)
B & K module cassette KK 0022, 2/12 of 19 in rack

WEIGHT: 1,45 kg (3,2 lb) including batteries

ACCESSORIES INCLUDED:
3 × 1,5 V Alkaline Cells ..... QB 0004
1 × 7-pin DIN plug ..... JP 0703
2 × Overlays ..... SC 0418

ACCESSORIES AVAILABLE:
Rechargeable Ni-Cd Cells ..... 3 × QB 0008
Battery Charger ..... ZG 0113
Power Supply ..... Type 2805
7-pin Plug for Preamp. Input of B & K Measuring Amplifiers and Analyzers ..... JP 0701

*The Acceleration mode 0,2 and 2 Hz -10% limits correspond to 0,1 and 1 Hz -3 dB limits

2. CONTROLS

2.1. FRONT PANEL

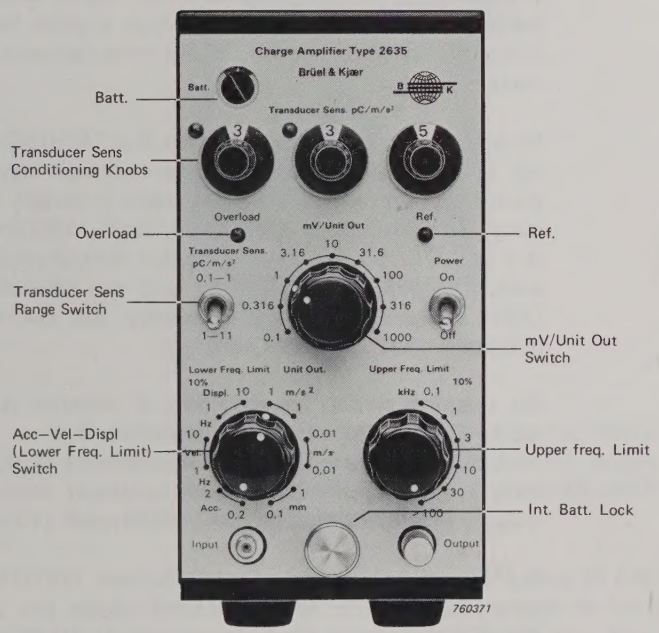


Fig.2.1. Front panel of 2635

POWER: "On-Off" switch for connection of the internal battery or external DC supply selected with the POWER SOURCE switch on the rear panel of the Amplifier. When power is connected one of the decimal point indicators above the TRANSDUCER SENS. pC/ms^{-2} knobs should light.

BATT.: Indicator for checking status of the internal battery or external voltage supply. With the Amplifier switched on, the indicator pointer should register within the green area. If not, replace or recharge the internal or external supply. See sections 3.1.3 and 3.4.

TRANSDUCER SENS. Range Switch: Toggle switch for selection of the 0,1 to 1 pC/ms^{-2} and the 1 to 11 pC/ms^{-2} ranges of the TRANSDUCER SENS. pC/ms^{-2} knobs. Should be set to the range corresponding with the charge sensitivity of the particular vibration measurement transducer employed.

TRANSDUCER SENS. Conditioning knobs: Three knobs for "dial-in" of exact transducer charge sensitivity from 0,1 to 1 pC/ms^{-2} or from 1 to 11 pC/ms^{-2} depending on the range selected with the TRANSDUCER SENS. pC/ms^{-2} range switch. Deci-

mal place indication is given by one of two LEDs (Light Emitting Diodes) situated above the knobs.

Note: With transducers of charge sensitivity between 0,100 and 0,109 pC/unit the left-hand TRANSDUCER SENS. conditioning knob should be set to ",1" and not ",10".

REF.: Self resetting push button switch which when pressed connects an internal 160 Hz (ω = 1000 rad/s) test source. May be used for checking the function of the 2635 as well as for calibration of recording and measuring instrumentation. See section 3.3.

OVERLOAD: A LED (Light Emitting Diode) which lights when the Amplifier is overloaded by input signals of too high a peak level. It responds to peak overloads as short as 20 μs and once actuated remains lit for approximately 1 s.

mV/UNIT OUT: Nine position switch which with the TRANSDUCER SENS. conditioning knobs adjusted to the excact charge sensitivity of the vibration transducer employed, may be used to select Amplifier output ratings ranging from 0,1 to 1 000 mV/ms^{-2}, 10 to 100 000 mV/ms^{-1} and 0,1 to 10 000 mV/mm. The exact output rating is the mV/UNIT OUT switch setting devided by the unit out selected with the ACC.—VEL.—DISPL. switch. When the overlay SC 0418 is used, this switch indicates UNITS/VOLT OUT.

ACC.—VEL.—DISPL. (LOWER FREQ. LIMIT): Six position switch for selection of vibration acceleration 1 ms^{-2}, velocity 0,01 ms^{-1} and displacement 0,1 — 1 mm unit out settings with Amplifier lower limiting frequencies of 0,2, 1, 2 and 10 Hz (10% down). At frequencies below the lower frequency limit the low frequency attenuation slope is 40 dB/decade (12 dB/octave).

UPPER FREQ. LIMIT: For selection of 0,1, 1, 3, 10, 30 and 100 kHz upper limiting frequencies (10% down). At frequencies above the upper limiting frequency the high frequency attenuation slope is 40 dB/decade (12 dB/octave).

INPUT: Microdot input socket for connection of measurement transducers. It has a maximum input charge rating of $\sim 10^5$ pC and accepts the B & K miniature accelerometer cables listed in section 5.3.

OUTPUT: Microdot output socket for connection of measuring and recording instrumentation. It accepts the miniature low noise cables listed in section 5.3 and produces a maximum output signal of 8 V (8 mA) peak. Its output impedance is less than 1 Ω but for maximum output it should not be loaded by less than 1 kΩ.

Note: The maximum DC offset voltage at the output socket is ± 50 mV, but can be adjusted to within more precise limits as in section 3.5.

INT. BATT. LOCK: Knurled thumb screw fastening the bottom panel of the 2635. One half turn counter clockwise will release the bottom panel for access to the battery compartment of the instrument.

2.2. REAR PANEL

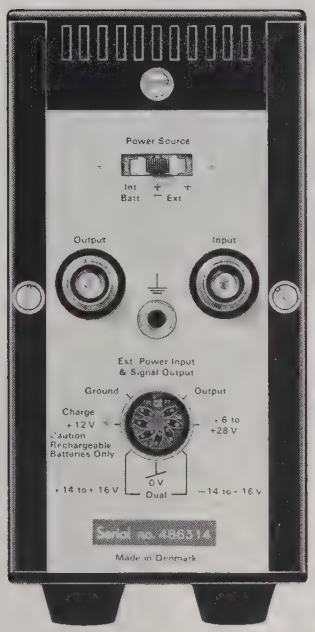


Fig.2.2. Rear panel of 2635

POWER SOURCE: Three position switch for powering the 2635 from its "Int. Batt." supply or from an "Ext. ±" or "Ext. +" DC supply which may be connected to the EXT. POWER INPUT & SIGNAL OUTPUT socket of the instrument. See section 3.4.

EXT. POWER INPUT & SIGNAL OUTPUT: 7 pin socket, accepting the DIN plug (B & K stock no. JP 0703) provided, for powering the 2635 as well as for recharging its internal battery supply from an external DC source. Also available on the socket is a signal output line for connection of recording and measuring instrumentation. For connections, see section 3.4.

INPUT: An alternative input connected in parallel with the input socket on the front panel. It accepts BNC coaxial plugs (B & K stock no. JP 0035) as well as a BNC-Microdot Adaptor JP 0145.

OUTPUT: An alternative output connected in parallel with the output socket on the front panel. It accepts BNC coaxial plugs (B & K stock no. JP 0035) as well as a BNC-Microdot Adaptor JP 0145.

CHASSIS: Socket accepting a banana plug (B & K stock no. JB 0002) for connection of the Amplifier chassis and signal ground line to the earth of a mains supply. To disconnect the Amplifier signal ground line from chassis, see section 3.1.4.

Warning: The 2635 is designed to be operated with its signal ground lines and chassis always at earth potential. Never let the signal ground terminals, socket screens or chassis float at any other potential, as this will impair the operating safety of the 2635 and may damage the instrument.

3. OPERATION

3.1. PRELIMINARY

3.1.1. Environment

Charge Amplifier Type 2635 may be used over a wide temperature range extending from −10 to +55°C (+ 14 to 131°F). For use in high humidity environments the Amplifier may be equipped with a small 3 W heatig element. This may be fitted on special order and helps prevent build-up of condensation which can introduce low frequency noise into the Amplifier. Its use however, is only recommended when the 2635 is powered from an external supply.

3.1.2. Mounting

The 2635 is designed to fit into the B & K Module System. Its metal cabinet may either be used free standing on its four rubber feet or with its bottom panel removed may be fitted into a 19 inch instrumentation rack using the metal frame KK 0014. This accepts up to 6 modular instruments of the same size as the 2635. For further information on the module system the B & K Short and Main Catalogues should be consulted.

3.1.3. Battery Installation

Dry Cells:

The 2635 is delivered with three 1,5 V non-rechargeable Alkaline Batteries Type LR 20 ("D" size), QB 0004. These are for use in the internal battery compartment of the instrument and when fitted provide approximately 100 hours of semi-continuous operation before needing to be replaced. Similar types of dry battery may be used for replacement, however, operating life will depend on the particular make and type of battery.

Rechargeable Cells:

The battery compartment of the 2635 also accepts rechargeable nickel cadmium cells. Suitable cells are QB 0008 which are available on separate order and have a voltage and charge rating of 1,2 V and 4 amp. hours respectively. They are more economical than conventional dry cells as they may be recharged a minimum of 500 times before needing to be replaced and with each charge provide approximately 80 hours of continuous operation. For recharging an external DC supply may be connected as shown in section 3.4.

Installation and Replacement of Cells:

The battery compartment of the 2635 is shown in Fig.3.1. To fit dry cells QB 0004 or rechargeable nickel cadmium cells QB 0008 proceed as follows:

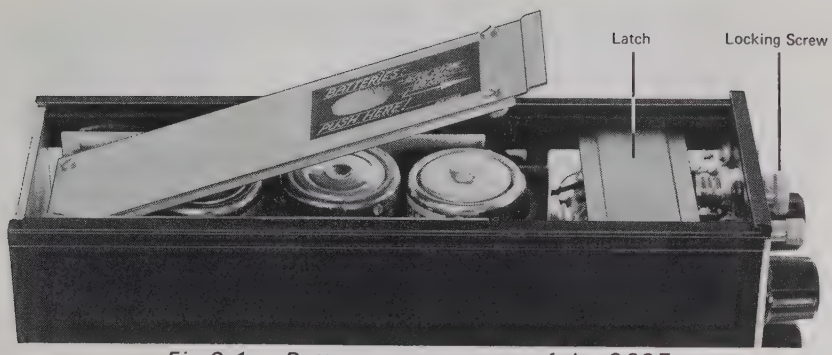


Fig.3.1. Battery compartment of the 2635 760372/1

1. Release and remove the bottom panel of the 2635 by turning the locking screw at the bottom of the front panel counter clockwise. Half a turn should be sufficient to release the panel which may removed by sliding it towards the rear of the instrument.

2. Release the lid of the battery compartment by pressing the front of the lid down and sliding its latch towards the front of the instrument. See Fig.3.1.

3. Hinge back the lid of the battery compartment and load three new dry or rechargeable cells. Care should be taken to ensure that the positive pole of each cell (stud on cell casing) faces the direction indicated in each channel of the compartment.

4. Close and lock the lid of the battery compartment and replace the bottom panel.

5. Label the 2635 stating which type of cells have been fitted. If alkaline or other non-rechargeable dry cells are used then also state "EXPLOSION RISK — NOT TO BE RECHARGED".

3.1.4. Grounding

Indiscriminate grounding of instruments can introduce ground loop interference. To prevent this it is necessary to ensure that the signal ground line of the 2635 and of other instruments with which it is used is grounded at one point only in the measurement system. To do this without prejudicing the operating safety of the measurement system, proceed as follow:

1. Connect the signal ground lines of all instruments together. This is done automatically through the screens of the input and output cables used to interconnect the instruments.

2. If instruments equipped with a mains socket chassis terminal are employed in the measurement arrangement then check that a) one and only one of these instruments has its signal ground line connected via chassis to mains ground and b) the housing of the measurement transducer is isolated from grounded measurement sources.

3. If the measurement arrangement is used free standing without the instrument cabinets touching, then ensure that each of the other instruments in the measurement arrangement has its chassis connected to a) mains ground only or b) chassis only. With instruments having a mains socket chassis terminal, a) is to be preferred.

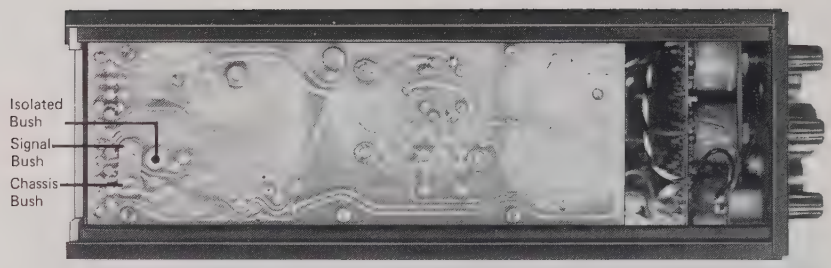


Fig.3.2. Signal-Chassis Ground connection accessible on removing the top panel of the 2635

4. If the measurement arrangement is mounted in a metal instrumentation rack, then ensure that one only one of the instruments has its signal ground line connected to chassis (and chassis connected to mains ground if equipped with mains socket chassis terminal). If more than one of the instruments has a permanent signal ground chassis connection, then isolate the chassis of these instruments from one another.

On delivery the signal ground line of the 2635 is connected to chassis by a contact plate fastened between the signal and chassis bushes shown in Fig.3.2. If necessary, the signal ground line may be isolated from chassis by unscrewing the plate and fastening it to the isolated bush shown in Fig.3.2. The contact bushes are on the printed circuit board immediately beneath the top panel which is fastened by a single screw on the rear panel of the 2635.

3.2. MEASUREMENT PROCEDURE

The output ratings obtained with 3 digit dial-in of transducer charge sensitivity on the 2635 are accurate to within 1%. Therefore for general purpose measurements relying on factory calibration of transducer charge sensitivity specified on the transducer calibration chart, only the indicating instrument with which the 2635 is used need be calibrated by the user.

The measurement procedure is as follows:

1. Carry out the necessary preliminary adjustments as in section 3.1.

2. Set the POWER SOURCE switch to "Int. Batt." and the POWER switch to "On".

   The pointer of the BATT. status indicator should now deflect to the green area. If in the red area or only just inside the green area then the cells contained in the battery compartment of the instrument should be replaced as in section 3.1.3. Nickel cadmium cells may be recharged as in section 3.4.1.

3. Connect the INPUT socket of a suitable indicating instrument — Voltmeter, Measuring Amplifier or Frequency Analyzer — to one of the two OUTPUT sockets on the 2635.

4. Calibrate the indicating instrument for non-selective (linear mode) voltage measurements as prescribed in the Instruction Manual for the instrument. After calibration, select the instrument's 3,16 V full scale meter range with the appropriate RMS or Peak meter function for measurements.

If necessary, other voltage measurement ranges of the indicating instrument may be used. However, the 3,16 V range makes best use of the dynamic range available with the 2635.

5. Observing the correct mounting and installation instructions for the measurement transducer, connect it to one of the two INPUT sockets on the 2635.

   To prevent hum pick-up, the INPUT socket not in use should be shielded using the Microsocket or BNC socket covers YM 0420 and DT 0074 provided.

6. Using the TRANSDUCER SENS. switch select the "1 — 11 pC/ms^{-2} " range for transducers with charge sensitivity equal to or greater than 1 pC/unit. If less than 1 pC/unit select the "0,1 — 1 pC/ms^{-2} " range.

7. Starting with the most significant digit (left hand knob) of the TRANSDUCER SENS. conditioning knobs dial-in the charge sensitivity value of the transducer in pC/unit.

   If the transducer charge sensitivity is less than 0,1 pC/unit or greater than 11 pC/unit, determine the exponent to be applied to the sensitivity value in order that it may be dialed in on the 2635 with the conditioning knob LEDS giving the correct decimal place indication.

Examples:

With accelerometer of charge sensitivity 125 pC/ms^{-2} dial-in "1,25" where 10^{+2} pC/unit is the exponent.

With Hydrophone of charge sensitivity 45,2 10^{-3} pC/Pa dial-in ",452" where 10^{-1} pC/unit is the exponent.

Note: With transducers of charge sensitivity between 0,100 and 0,109 pC/unit the left hand TRANSDUCER SENS. conditioning knob should be set to ",1" not ",10".

8. Set the UPPER FREQ. LIMIT switch to a frequency just above the highest measurement frequency of interest. Unwanted signals and noise above the selected frequency will then be attenuated by the Amplifier.

9. Set the ACC.—VEL.—DISPL. switch to the appropriate vibration unit out and lower frequency limit for measurements.

   When using transducers other than vibration measurement types select the "0,2 Hz Acc." or "2 Hz Acc." mode only. The unit out is then the measurement unit in which the transducer is calibrated e. g. 1 N or 1 lbf with force transducers —1 Pa with hydrophones.

   To limit low frequency noise with accelerometers not having a low temperature transient sensitivity use the 2 or 10 Hz low frequency limit modes of the switch.

10. Apply the signal to be measured and switch the mV/UNIT OUT switch to obtain a suitable meter deflection on the indicating instrument without causing the OVERLOAD LED on the 2635 to light. If the deflection is insufficient, even after adjustment of the mV/UNIT OUT switch, then switch the indicating instrument to a more sensitive voltage range.

To determine the output sensitivity S_p of the 2635, the following relation may be used:

$$S_p = \frac{\text{mV/UNIT OUT switch setting} \times \text{exponent determined in item 7}}{\text{Unit Out selected with ACC.—VEL.—DISPL. switch}}$$

With transducers of charge sensitivity between 0,1 and 10,99 pC/Unit the exponent is 10^0 (i. e. 1.) and therefore can be ignored.

The signal level L_{FSD} corresponding to full scale meter deflection on the indicating instrument may be determined using:

$$L_{FSD} = \frac{\text{Voltage range } V_{FSD} \text{ selected on indicating instrument}}{\text{Output sensitivity } S_p \text{ of 2635}}$$

Example — Accelerometer Charge Sensitivity 2,1 pC/ms^{-2}

Set the Amplifier TRANSDUCER SENS. range switch and conditioning knobs to "1 — 11" and "2,10" pC/ms^{-2} respectively. Assuming that the ACC.—VEL.—DISPL. switch is set to a vibration velocity unit out of "0,01 ms^{-1} " with the mV/UNIT OUT switch set to "100" mV/unit out, then the velocity corresponding to full scale meter deflection on the indicating instrument when its 3,16 V range is used, is given by:

$$L_{FSD} = \frac{V_{FSD}}{S_p}$$

$$= \frac{3{,}16}{100\ 10^{-3}/0{,}01\ \text{ms}^{-1}} = \frac{3{,}16}{10/\text{ms}^{-1}}$$

$$L_{FSD} = 0{,}316\ \text{ms}^{-1}$$

Example — Accelerometer Charge Sensitivity 3,5 10^{-3} pC/ms^{-2} (i.e. 0,35 10^{-2} pC/ms^{-2})

Set the Amplifier TRANSDUCER SENS. range switch to "0,1 — 1" pC/unit and noting the exponent 10^{-2} pC/ms^{-2} , dial-in ",350" using the TRANSDUCER SENS. conditioning knobs. Assuming that the ACC.—VEL.—DISPL. switch is set to a vibration acceleration unit out of "1 ms^{-2} " with the mV/UNIT OUT switch set to "1000" mV/unit out, then the acceleration corresponding to full scale meter deflection on the indicating instrument when its 3,16 V range is used, is given by:

$$L_{FSD} = \frac{V_{FSD}}{S_p}$$

$$= \frac{3{,}16}{1000\ 10^{-3}\ \ 10^{-2}/1\ \text{ms}^{-2}} = \frac{3{,}16}{0{,}01/\text{ms}^{-2}}$$

$$L_{FSD} = 316\ \text{ms}^{-2}$$

Example — Force Transducer Charge Sensitivity 4,04 pC/N

Set the Amplifier TRANSDUCER SENS. range switch and conditioning knobs to "1 — 11" and "4,04" pC/unit respectively. With the ACC.—VEL.—DISPL. switch set to "1 ms^{-2} " (corresponds to a unit out of 1 N for force measurements) and the mV/UNIT OUT switch set to "3,16" mV/unit out, the force corresponding to full scale meter deflection on the indicating instrument when its 100 mV range is used, is given by:

$$L_{FSD} = \frac{V_{FSD}}{S_p}$$

$$= \frac{100 \quad 10^{-3}}{3{,}16 \quad 10^{-3}/1\,N} = \frac{100}{3{,}16/N}$$

$$L_{FSD} = 31{,}6\,N$$

Example — Hydrophone Charge Sensitivity 43,1 10^{-3} pC/Pa (i.e. 0,431 10^{-1}pC/Pa)

Set the Amplifier TRANSDUCER SENS. range switch to "0,1 — 1" pC/unit and noting the exponent 10^{-1} pC/Pa, dial-in ",431" using the TRANSDUCER SENS. conditioning knobs. With the ACC. — VEL. — DISPL. switch set to 1 ms^{-2} (corresponds to unit out of 1 Pa for underwater sound pressure measurements) and the mV/UNIT OUT switch set to "1000" mV/unit out, the sound pressure corresponding to full scale meter deflection on the indicating instrument when its 316 mV range is used, is given by:

$$L_{FSD} = \frac{V_{FSD}}{S_p}$$

$$= \frac{316 \quad 10^{-3}}{1000 \quad 10^{-3} \quad 10^{-1}/1\,Pa} = \frac{316}{100/Pa}$$

$$L_{FSD} = 3{,}16\,P_a$$

3.2.1. Measurement Procedure using Overlay SC 0418

The overlay SC 0418 can be used to simplify the measurement procedure described in section 3.2. It is secured to the front panel of the 2635 by removing the knob on the mV/UNIT OUT switch and sticking it over the existing printed scale so it now reads UNITS/VOLT OUT.

The measurement procedure is now as follows:

1. Carry out the preliminary adjustment described in sections 3.1. and steps 1, 2, 3, 5, 6 and 7 in section 3.2.

2. On the indicating instrument select a measurement range of 1 V FSD.

3. The setting on the UNITS/VOLT OUT switch now indicates the value of an FSD in ms^{-2}, ms^{-1} or mm, depending on the setting of the UNIT OUT switch on the 2635.

Example:

An accelerometer and 2635 combination is used to measure a vibration level. The output of the 2635 is fed into a measuring amplifier. The arrangement is set up according to the outlines above. Measurements are made in the acceleration mode i.e. ms^{-2} units.

The UNITS/VOLT switch is set to 100. This means that a FSD on the measuring amplifier is equivalent to 100 ms^{-2}. Consequently a reading of, say, 500 mV is simply equivalent to exactly one half of this, i.e. 50 ms^{-2}.

Likewise a setting of 10 on the UNITS/VOLT switch is equivalent to an FSD of 10 ms^{-2}.

3.3. USE OF INTERNAL TEST SOURCE

The internal test source of the 2635 generates a 160 Hz (ω = 1000 rad/s) sinusoidal signal. This may be used in checking the correct function of the Amplifier or as a reference for determining levels of measured signals recorded on tape. It is connected to the input stage of the Amplifier when the REF. push button is pressed and is adjusted at B & K to produce at test voltage level of 1 VRMS at the OUTPUT sockets of the Amplifier. This is obtained with the Amplifier acceleration mode control settings specified in Table 3.1. With the velocity and displacement modes the test voltage output level is reduced to 100 and 10 mV respectively, due to attenuation by the integration stages of the Amplifier.

mV/UNIT OUT setting	TRANSDUCER SENS conditioning setting	OUTPUT REFERENCE LEVEL		
"10"	"1,00"	1 V_{RMS}	100 mV_{RMS}	10 mV_{RMS}
	"1,41"	1 V_{peak}	100 mV_{peak}	10 mV_{peak}
ACC–VEL–DISPL SWITCH SETTING		"Acc-2 Hz"	"Vel-10 Hz"	"Displ-10 Hz"

760040

Table 3.1. Test voltage output levels available with different control settings on the 2635

To check the correct function of the 2635 a voltmeter or other indicating instrument may be used to measure the test voltage. With the Amplifier control settings prescribed in Table 3.1, the test voltage output levels should be within ± 2% of the values specified.

For determining absolute levels with tape recorded measurements first record the measured signal from the output of the 2635 and then note the output sensitivity S_p of the Amplifier (see section 3.2 item 10). Without changing the input sensitivity of the recorder adjust the controls of the Amplifier as prescribed in Table 3.1 and press its REF push button to record the 1 V test signal. On playback the amplitude of the recorded test signal will correspond to a reference level

$$L_r = \frac{1}{S_p}$$

which when compared with the recorded measurement will enable the absolute level of the measurement to be determined.

For further information in determining absolute levels of tape recorded data the Instruction Manual for the B & K Tape recorder Types 7005, 7006 and 7007 should be consulted.

3.4. USE OF EXTERNAL POWER SUPPLY

For connection of an external DC supply use may be made of the EXT. POWER INPUT & SIGNAL OUTPUT socket on the rear panel of the 2635. This accepts the 7 pin DIN plug (B & K stock no. JP 0703) supplied and has the pin identities shown in Fig.3.3.

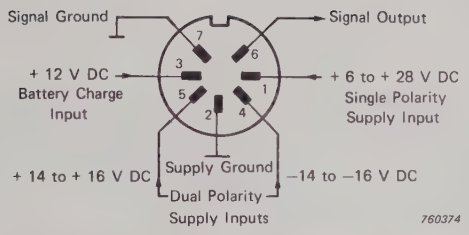


Fig.3.3. EXT. POWER INPUT & SIGNAL OUTPUT socket of the 2635 (external view)

3.4.1. Recharging Nickel Cadmium Cells

When nickel cadmium cells are used in the battery compartment of the 2635 they may be recharged without having to remove them from the Amplifier. A charging unit is built-in which may be powered by connecting the positive line of an external 12 V supply to pin 3 of the EXT. POWER INPUT socket with current return line of the supply connected to supply ground pin 2. Suitable types of supply are discussed in section 5.2. The maximum current consumption is 300 mA.

Once connected the external supply will immediately begin to recharge the nickel cadmium cells with either mode of the Amplifier POWER "On" — "Off" switch selected. With the "Off" mode totally discharged cells take approximately 19 hours to recharge, whilst with the "On" mode in which the external supply also powers Amplifier for measurements, the recharge time is approximately 23 hours. Alternatively a separate external supply may be used to power the Amplifier (see section 5.2) in which case maximum recharge time is kept to 19 hours.

To check the charge state of the cells, set the POWER SOURCE switch to "Int. Batt." and use the BATT. level indicator on the front panel of the Amplifier. For a correct indication the external supply used to charge the cells must be disconnected from the Amplifier. If cells fail to reach a fully charge state after being left on charge for 19 hours or more then they should be replaced, as shown in section 3.1.3.

WARNING: DO NOT ATTEMPT TO RECHARGE ALKALINE OR NON-RECHARGEABLE DRY CELLS. ONLY RECHARGEABLE NICKEL CADMIUM CELLS MAY BE RECHARGED WITHOUT RISK OF EXPLOSION.

3.4.2. Powering the 2635

Power for the amplifier circuitry of the 2635 may be provided by a single polarity DC supply with voltage between + 6 and + 28 V (55 mA) or from a dual polarity DC supply with voltage between ± 14 and ± 16 V (14 mA). For single polarity operation set the POWER SOURCE to "Ext. +" and connect the positive line of the supply to pin 1 of the EXT. POWER INPUT socket. For dual polarity operation select the "Ext. ±" mode of the POWER SOURCE switch and connect the positive line of the supply to pin 5 with its negative line to pin 4. The current return line for single and dual polarity supplies is via supply ground pin 2.

Suitable types of supply which may be used to power the 2635 are discussed in section 5.2.

3.5. ADJUSTMENT OF OUTPUT DC OFFSET VOLTAGE

Each 2635 is individually adjusted at B & K so that the DC offset voltage at its output is zero. However, after periods of long service or rough handling it is advisable to check that the Amplifier has not become misadjusted as this will limit the dynamic range of the measurement system, particularly when DC coupled indicating and recording equipment is used with the Amplifier.

To check and adjust the output DC offset voltage proceed as follows:

1. Remove the top and left side panels of the 2635 by sliding them towards the rear of the instrument. The panels are fastened by screws on the rear panel.

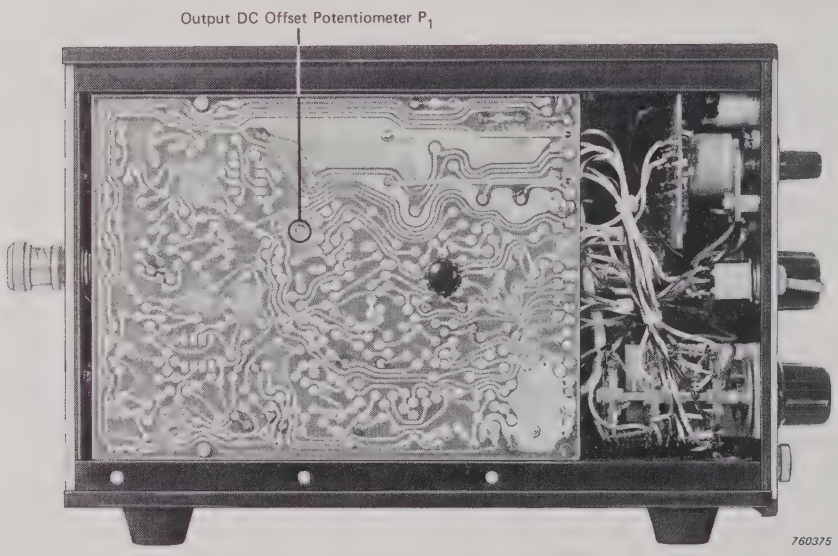


Fig.3.4. Output DC offset voltage adjustment potentiometer P_1

2. Check that the signal ground line of the 2635 is connected to chassis as shown in section 3.1.4. Once checked, replace the top panel.

3. Switch the Amplifier "On" and adjust its output sensitivity by selecting the following control settings:

TRANS. SENSITIVITY range switch	"1 — 11" pC/unit
TRANS. SENSITIVITY conditioning knobs	"1,00" pC/unit
mV/UNIT OUT switch	"100"
ACC.—VEL.—DISPL. switch	"Acc. — 2 Hz"

   To prevent hum pick-up screen both INPUT sockets of the Amplifier using the socket covers YM 0420 and DT 0074 provided.

4. Connect a DC voltmeter such as the B & K Digital Type 2427 to one of the OUTPUT sockets and using a small screwdriver adjust the preset potentiometer P_1 shown in Fig.3.4 so that the output DC offset voltage indicated by the voltmeter is zero. Check that the offset voltage remains zero when the side panel of the Amplifier is replaced.

5. Switch the Amplifier "Off" and replace the left side panel making the Amplifier ready for use.

4. CHARACTERISTICS

4.1. OVERALL GAIN

The overall gain of the 2635 for various settings of its TRANSDUCER SENS. and mV/UNIT OUT knobs with the "Acc" modes of the LOWER FREQ. LIMIT knob selected is given in Table 4.1.

Transducer Sens-Range (pC/ms^{-2})	Conditioning knob setting	Amplifier Gain (dB)								
0,1 to 1	,100	0	10	20	30	40	50	60	70	80
	,999	−20	−10	0	10	20	30	40	50	60
1 to 11	1,00	−20	−10	0	10	20	30	40	50	60
	10,00	−40	−30	−20	−10	0	10	20	30	40
mV/Unit Out Knob setting		0,1	0,316	1	3,16	10	31,6	100	316	1000

790121

Table 4.1. Overall gain of the 2635 with 1 nF source capacitance

4.2. FREQUENCY AND PHASE

The overall frequency and phase characteristics of the 2635 are shown in Figs.4.1 and 4.2 respectively. For the majority of measurements the ACC.—VEL.—DISPL. (LOWER FREQ. LIMIT) and UPPER FREQ. LIMIT switches of the Amplifier may be set so that amplitude and phase shift errors over the frequency range of interest are insignificiant. However, for measurements at frequencies less than 10 times the selected lower frequency limit and at frequencies greater than 0,1 times the selected upper frequency limit, the introduction of phase non linearities cannot be avoided.

As far as measurement of periodic signals are concerned the presence of phase non linearities have no influence on the measurement of RMS levels. However, with signals containing low as well as high level frequency components they distort the signal waveform preventing accurate measurement of peak levels. For this reason when dealing with complex signals such as shocks and impulses the linear "Acc. — 0,2 Hz" mode should be employed. It is not recommend to integrate single shocks or impulses using the "Vel." or "Displ." modes.

For applications requiring the use of two 2635 Amplifiers such as in mechanical impedance measurements or in calibration of transducers using the 2970 Sensitivity Comparator, it is necessary to determine the resulting phase error in the measurement or calibrtation system. For this purpose the maximum phase deviation between any two 2635 Amplifiers may be found from Fig. 4.2 by taking into account that the tolerance on the lower and upper frequency limits is ± 10%.

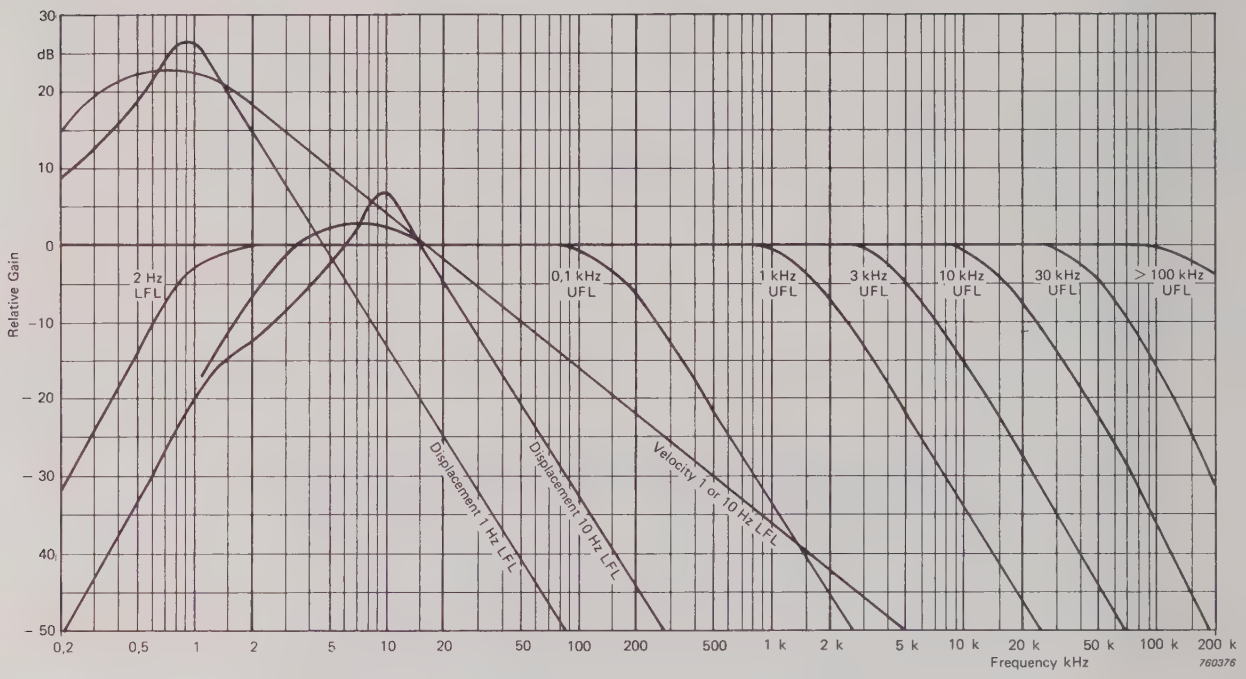


Fig.4.1. Typical overall frequency characteristics of the 2635

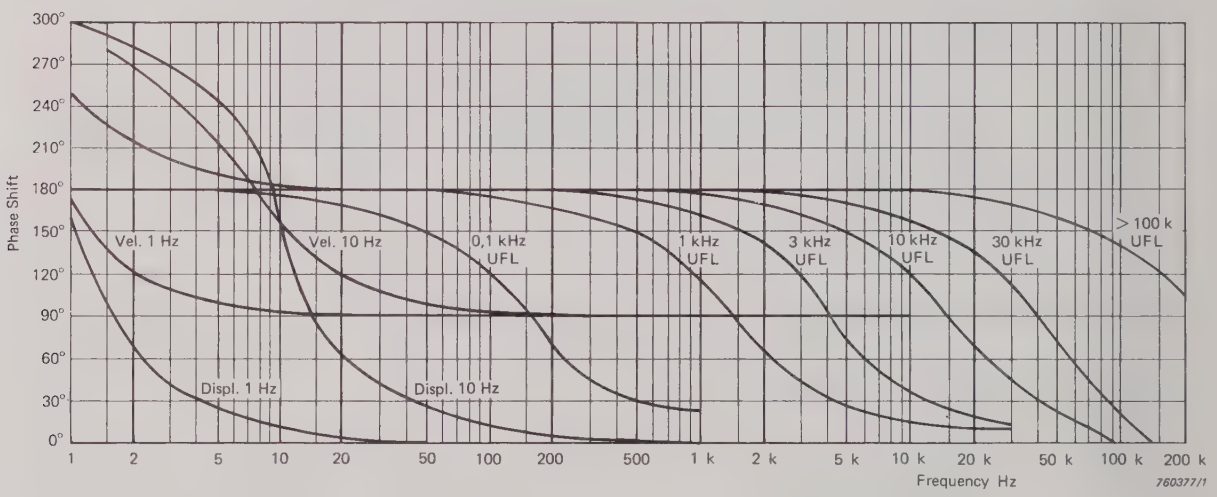


Fig.4.2. Typical phase characteristics of the 2635

4.3. INFLUENCE OF CAPACITANCE LOADING

Typical frequency characteristics of the 2635 as a function of input and output load capacitance and mV/UNIT OUT switch setting are given in Figs.4.3, 4.4 and 4.5. These may be used to determine what lengths of input and output cable may be employed without their shunt capacitance influencing the frequency range of interest for measurements. For instance, Fig.4.3 and 4.5 indicate that for measurements at frequencies up to 10 kHz the Amplifier may be used with an input load capacitance of 50 nF and an output load capacitance of 20 nF. Thus with cables having a shunt capacitance of 100 pF/m up to 500 m of input cable and 200 m of output cable may be employed.

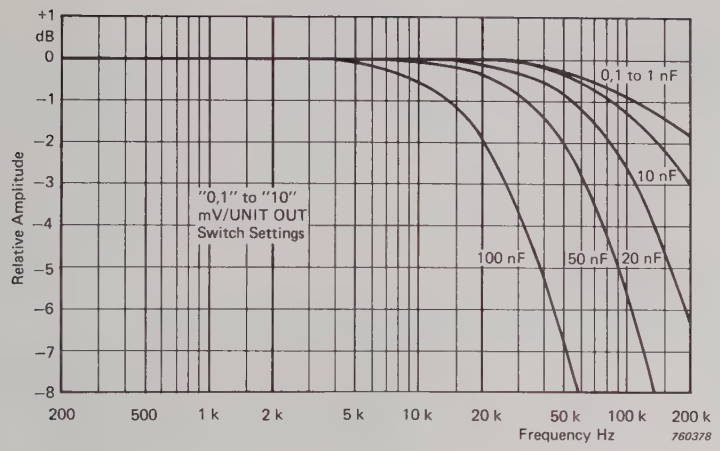


Fig.4.3. Influence of input load capacitance on the frequency response of the 2635 with "0,1" to "10" mV/UNIT switch settings

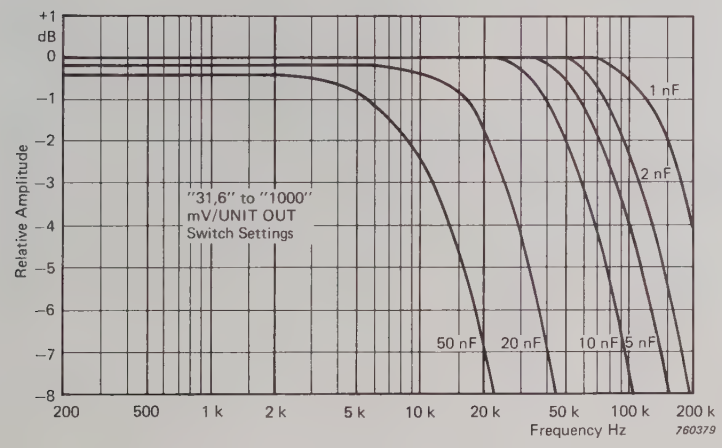


Fig.4.4. Influence of input load capacitance on the frequency response of the 2635 with "31,6" to "1000" mV/UNIT switch settings

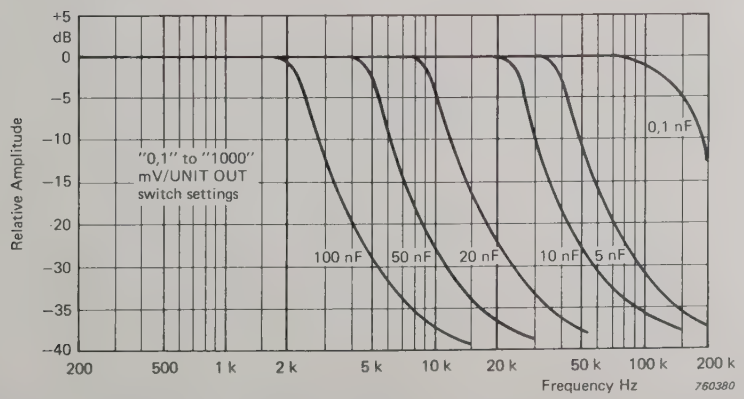


Fig.4.5. Influence of output load capacitance on the frequency response of the 2635

Comparison of Figs.4.3 and 4.4 shows that the influence of input load capacitance on the frequency response of the Amplifier is more pronounced with the "31,6" to "1000" settings than with the "0,1" to "10" settings of the mV/UNIT OUT switch. Since it also influences the noise characteristics of the Amplifier (see section 4.3) long input cables having a very high shunt capacitance should be used with care.

4.4. NOISE AND DYNAMIC RANGE

A third octave analysis of broadband (2 Hz to 100 kHz) noise produced by the 2635 is shown in Fig.4.6. This was measured with the Amplifier set for minimum sensitivity ("10,00" pC/unit — "0,1" mV/unit out) with a 1 nF capacitor terminating the input simulating the source capacitance of a transducer plus connection cable. Over the linear 2 Hz to 22 kHz frequency range the typical output noise level is 7,5 μV which for a maxi-

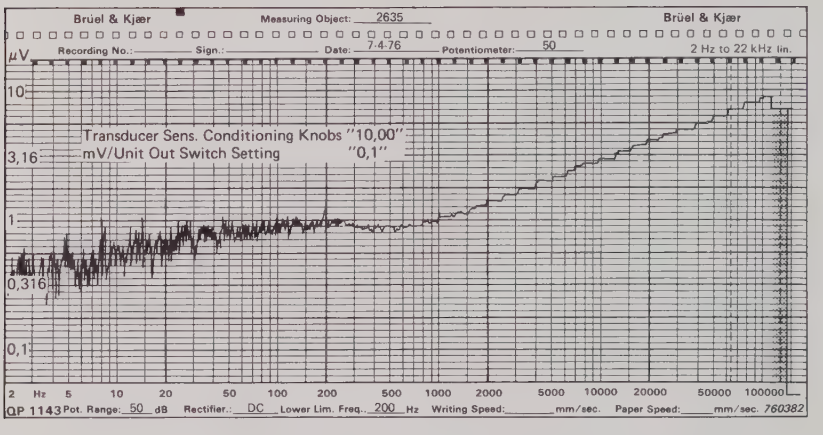

Brüel & Kjær
Measuring Object: 2635
Brüel & Kjær
μV
Recording No.:
Sign.:
Date: 7-4-76
Potentiometer: 50
2 Hz to 22 kHz lin.
10
Transducer Sens. Conditioning Knobs "10,00"
3,16
mV/Unit Out Switch Setting "0,1"
1
0,316
0,1
2 Hz 5 10 20 50 100 200 500 1000 2000 5000 10000 20000 50000 100000
QP 1143 Pot. Range: 50 dB Rectifier: DC Lower Lim. Freq.: 200 Hz Writing Speed: mm/sec. Paper Speed: mm/sec. 760382

Fig.4.6. Third octave noise spectrum produced by the 2635 with a source capacitance of 1 nF terminating the input of the Amplifier

mum output signal level of 5,5 V RMS (8 V peak) represents a signal to noise ratio of over 110 dB. With maximum amplifier sensitivity (",100" pC/unit — "1000" mV/unit out) the typical output noise level is 18 mV representing a signal to noise ratio of 50 dB.

With higher values of input source capacitance the Amplifier noise level is increased as shown in Fig.4.7. From this it can be seen that the high sensitivity mV/UNIT OUT switch settings should be used with care.

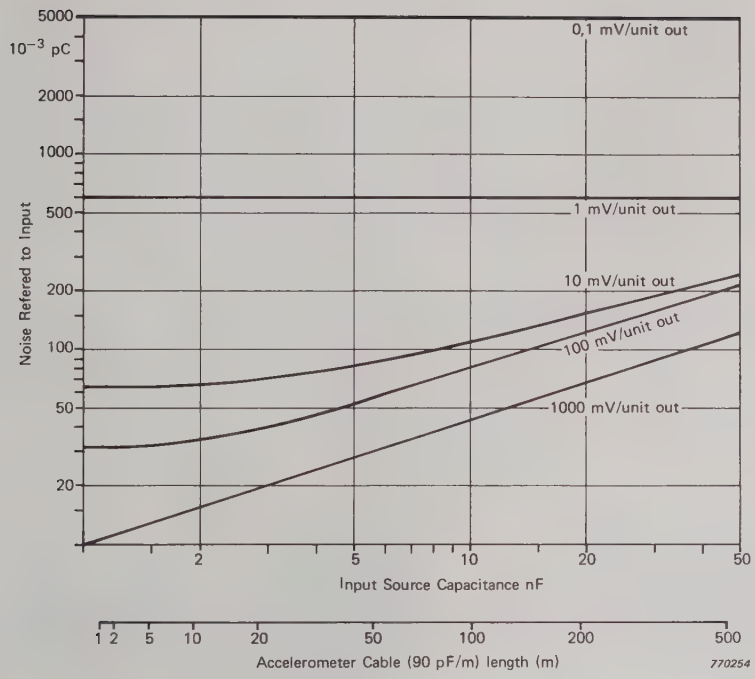


Fig.4.7. Broadband 2 Hz to 100 kHz noise with the 2635 as a function input source capacitance

5. ACCESSORIES

5.1. MEASURING AND RECORDING INSTRUMENTATION

B & K produce a wide range of measurement and analysis equipment. For further details consult the B & K Short and Main Catalogues.

5.2. EXTERNAL POWER SUPPLIES

5.2.1. B & K Measuring Amplifiers and Frequency Analyzers

A convenient way of powering the 2635 other than using its internal battery supply is to use the + 12 V preamplifier supply of one of the B & K Measuring Amplifiers or Frequency Analyzers. The supply is available at the PREAMP. INPUT socket of the instruments and therefore only one cable need be employed for connecting the external power input and signal output lines of the 2635. Connections are as shown in Fig. 5.1 and are made using the 7 pin Preamplifier plug JP 0701 and DIN plug JP 0703. For operation from the supply the POWER SOURCE switch of the 2635 should be set to "Ext. +".

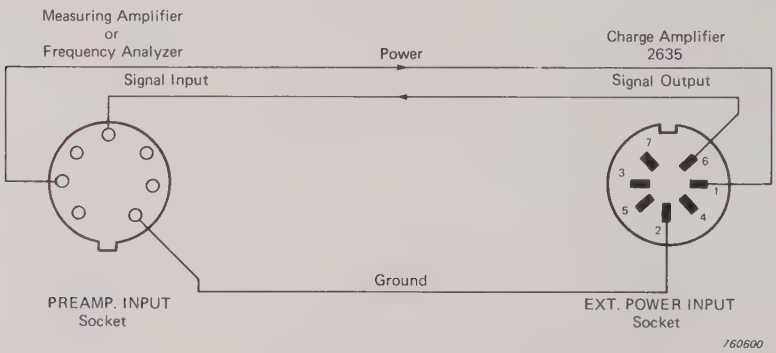


Fig. 5.1. Cable connections for powering the amplifier circuitry of the 2635 from the + 12 V (55 mA) preamplifier supply of a B & K Measuring Amplifier or Frequency analyzer. Soldering side of plugs shown

The maximum output current available from the + 12 V preamplifier supply is 200 mA. This is suitable for powering the amplifier circuitry of the 2635 but not for recharging its built-in battery supply. For this purpose a second external supply such as the Battery Charger ZG 0113 must be connected. See section 5.2.2.

5.2.2. Battery Charger ZG 0113

This is shown in Fig. 5.2 and is a mains operated supply providing an unregulated + 12 V (400 mA) DC suitable for recharging nickel cadmium cells QB 0008. It is supplied already fitted with a suitable output cable and plug for direct connection to the EXT. POWER INPUT socket of the 2635. This enables cells to be recharged without having to remove them from the battery compartment of the Amplifier. By setting the Amplifier POWER SOURCE switch to "Int. Batt.", it may be used to power the Amplifier for measurements whilst recharging.

For operation from different mains supply voltages the mains input cable of the Battery Charger has the following colour coding:

Blue	Neutral
Black	100 to 130 V AC
Brown	200 to 240 V AC

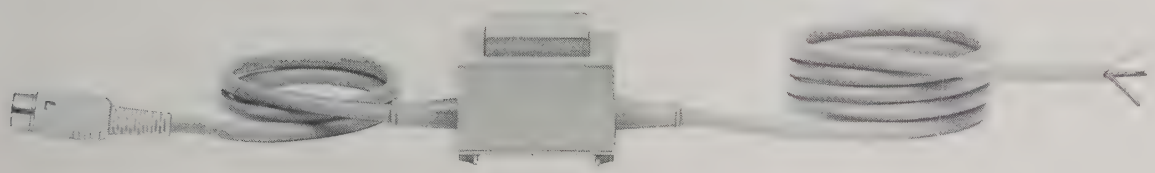


Fig. 5.2. Battery Charger ZG 0113

⚠ **Warning**! For maximum operating safety the free end of the particular input lead not used to connect the mains supply should be clipped short and covered with insulating tape.

5.3. ACCELEROMETER CABLES AND PLUGS

For connection of B & K piezoelectric accelerometers and force transducers to the 2635 the miniature low noise cables specified in Table 5.1 may be used. These are fitted with suitable plugs for standard as well as miniature types of transducer.

B & K Cable Type	Part Identities	Material	Max. Temp	Length	Capacitance (typical)
AO 0038	AC 0005 Plug — Plug JP 0012 JP 0012	Teflon insulated mininoise cable	260°C (500°F)	~ 1,2 m (4 ft)	~ 105 pF
AO 0231	AC 0005 Plug — TNC JP 0012 Connector	Teflon insulated mininoise cable	260°C (500°F)	~ 3 m (10 ft)	~ 260 pF
AO 0122	Miniature Plugs AC 0200 Reinforced	Teflon insulated mininoise cable	260°C (500°F)	~ 3 m (10 ft)	~ 300 pF
AO 0283	M3 10–32 Plug — UNF Plug AC 0205 JP 0012	Teflon insulated mininoise cable	260°C (500°F)	~ 1,2 m (4 ft)	~ 132 pF

T00980GB0

Table 5.1. Miniature low noise transducer cables supplied with plugs

If longer cables are required, then those specified in Table 5.1 may be interconnected using the extension connectors JJ 0032 shown in Fig. 5.3. Alternatively, Teflon insulated, mini-noise cable AC 0005 may be ordered in lengths up to 100 m without plugs fitted. In this case miniature plugs from the plug mounting kit UA 0130, may be fitted by the user. For mounting the plugs the assembly tool QA 0035 is required.

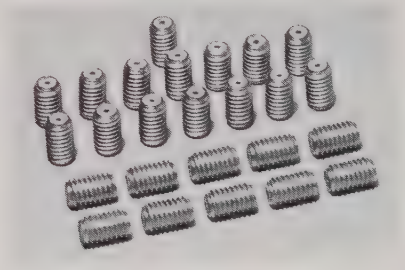
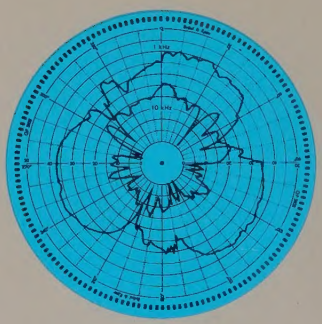
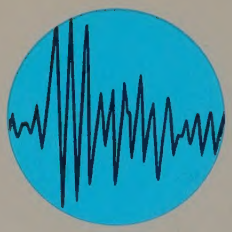


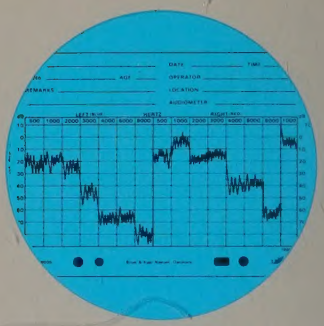
Fig. 5.3. Cable Connector SET UA 0186. Contains 25 extension connectors JJ 0032

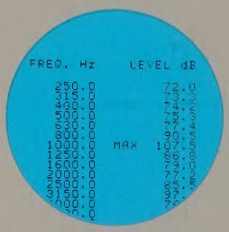
6. SERVICE AND REPAIR

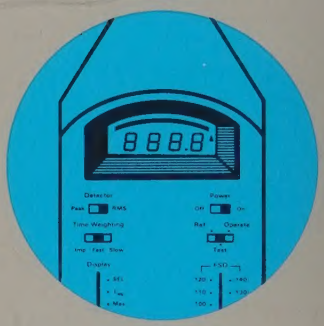
The 2635 is designed and constructed to provide the user with many years of trouble free operation. However, should a fault occur which impairs its correct function, then all power should be disconnected to prevent the risk of further damage. For repair consult the separate Service Manual provided or consult your local B & K service representative. Under no circumstance should repair be attempted by persons not qualified in the service of electronic instrumentation.

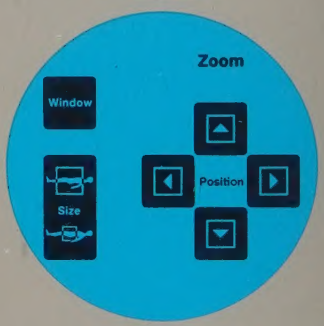


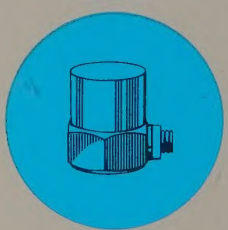


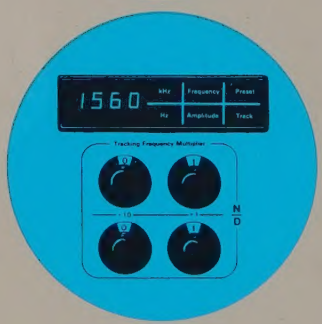


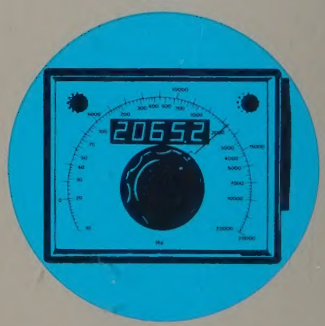


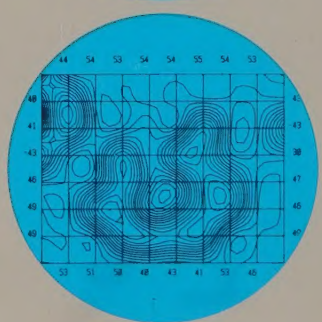


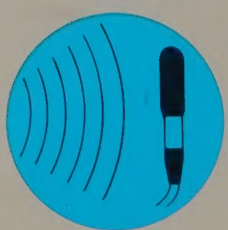


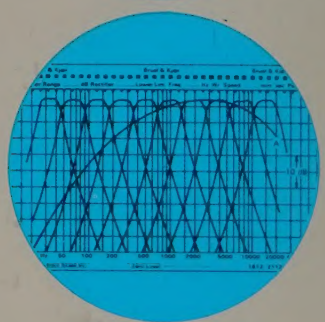












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